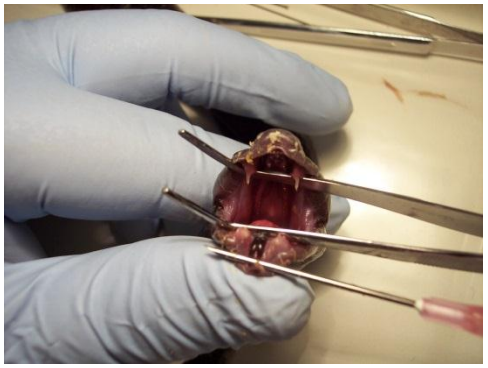
Medical Entomology

Vectors of Disease, Bites, Stings, and Direct Injuries



Vector Borne Disease Key Facts

- Account for 17% of all infectious diseases and causing 1M deaths annually.
- There are more than 1B cases and over 1M deaths from vector-borne diseases such as:
  - 2.5B people are at risk of contracting dengue annually
  - 600K – 1million people die of malaria annually
  - Millions around the world are affect by things like: . Schistosomiasis, African trypanosomiasis, lesihmaniasis, Chagas disease, yellow fever;
- Distribution of these disease are determined by a complex dynamic of environmental and social factors.

In the Top 25 Most Dangerous Animals

1 Mosquitoes

6 Brazilian Wandering Spider

7 Carpet Viper

9 Tse Tse Fly

13 Boomslang (snake)

19 Black Mamba

24 Africanized Honey Bee

25 Death stalker Scorpion

Agenda

- What is a “Vector”
  - Types of transmission
  - Vectors and Disease
- Physical Threat
  - Bites and Stings
  - Direct Injuries
- Understanding the Threat
- Prevention
- Resources

What is a “Vector”

- A “vector” can refer to many things depending on what context it is being used.
- In entomology the term Vector “means an arthropod that transmits a pathogen.”
- There are two types of Vectors:
  - Mechanical – vector physically moves the pathogen without it reproducing (examples: filth flies and cockroaches)
  - Biological – the pathogen replicates in the vector (examples: Mosquitoes, sand flies, ticks, fleas, biting flies, lice, etc…)

Vector Potential

- The potential for a specific vector under certain circumstances to transmit a specific pathogen.
- Not every arthropod can transmit a pathogen.
- Some arthropods can transmit one type of pathogen but not another.
- Many arthropods do not transmit any pathogens regardless of the circumstances.

Types of Biological Transmission

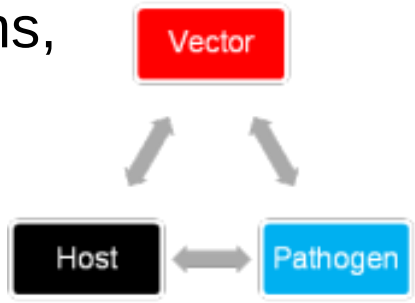
- Inoculation (mosquitoes)
- Regurgitation (filth flies)
- Fecal contamination (kissing bugs/flies)
- Contamination from crushing vector (Body Lice)

Vectors and Diseases

Vector	Disease
Aedes spp.	Dengue fever, Rift Valley fever, Yellow fever, Chikungunya
Anopheles spp	Malaria
Culex spp	Japanese encephlitis, Lymphatic filariasis, West Nile fever
Sand Flies	Leishmaniasis, Sandfly fever
Ticks	CCHF, TBE, Lyme disease, Relapsing fever, Spotted Fever, Q fever, Rocky Mountain Spotted Fever, Tularaemia, Erhlicosis
Triatomine (Assasin Bugs)	Chagas Disease
Fleas	Plague
Black flies	River blindness (Onchocerciasis)
Aquatic snails	Schistosomiasis

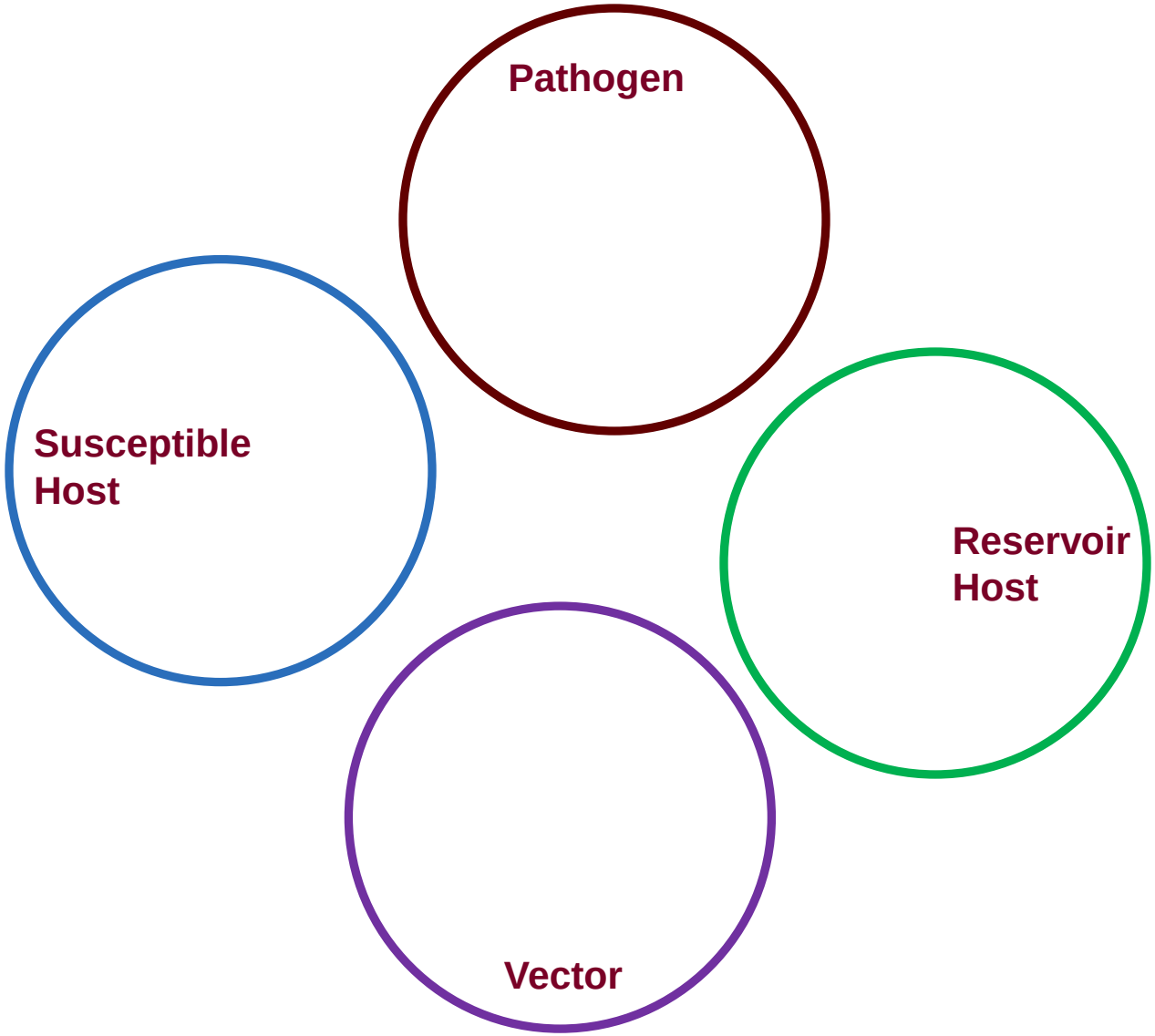
Components of Transmission

- **Pathogen**
  - Where does it normally occur? Animal host (Enzootic)? In this region (Endemic)?
- **Vector (Intrinsic)**
  - Feeding behavior, host preference, habitat, vector competence, density, life span
- **Host and reservoir populations**
  - Susceptibility, immunity, density, living conditions, movement
- **Landscape (Extrinsic)**
  - Climate, rainfall, temp, humidity, elevation, habitat



Where can you break the cycle?

Vector Disease Transmission



The Nature of Disease

Enzootic Cycle

Sand fly vector

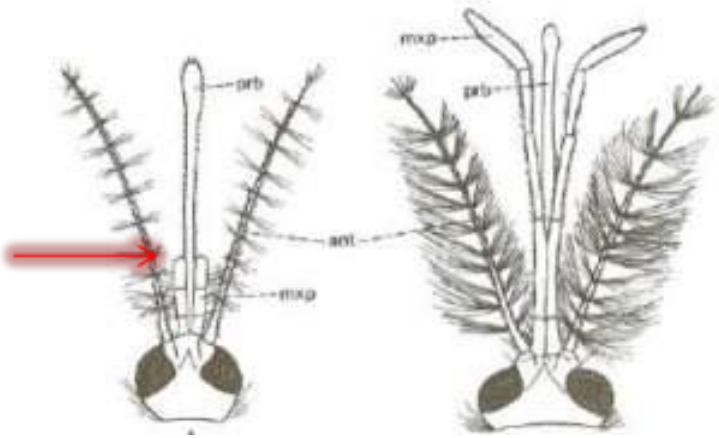
Mammalian Reservoir (home to the pathogen)

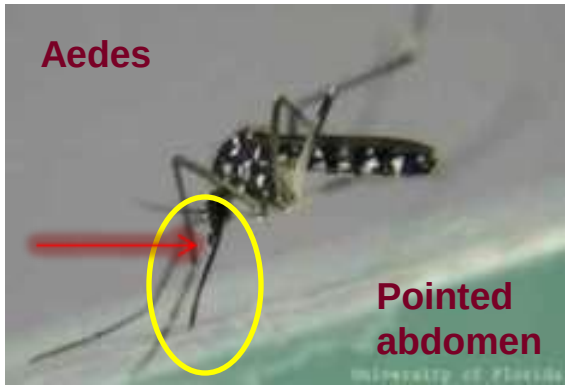
Incidental Host

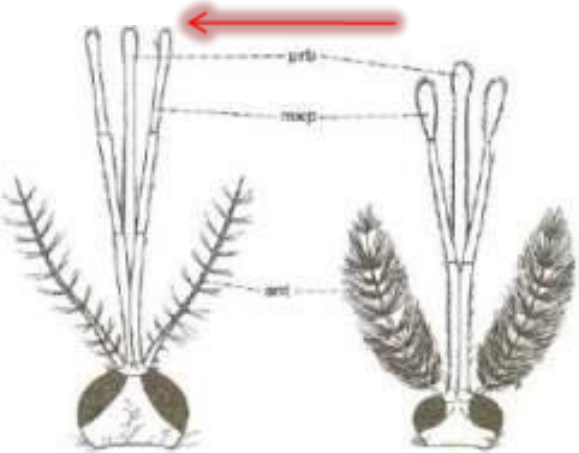
Man and his Activities

MOSQUITOS

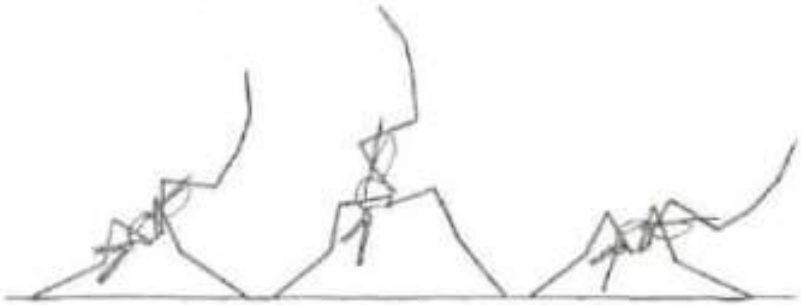
Mosquito Comparison



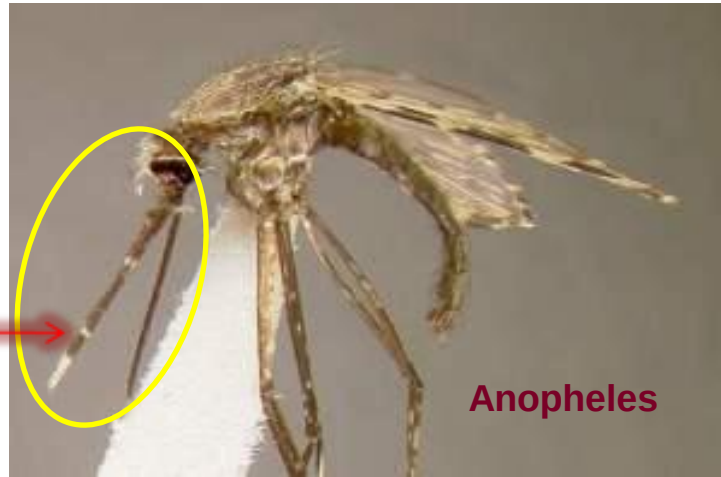




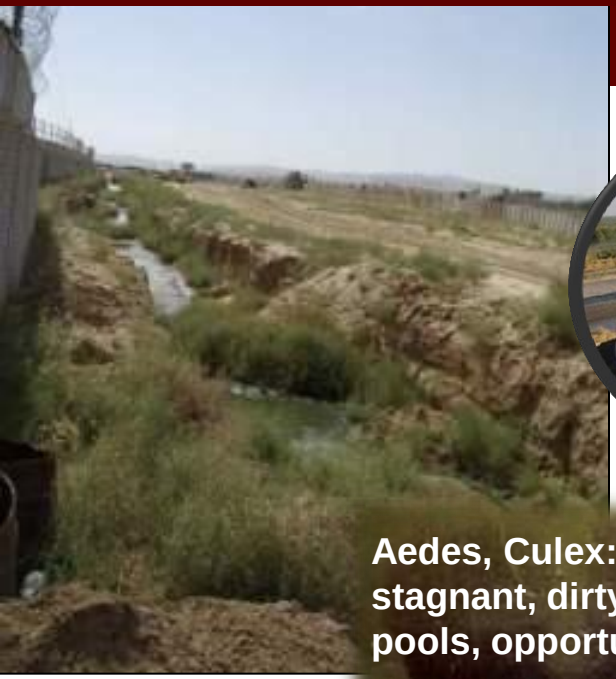
Length of palps compared to proboscis

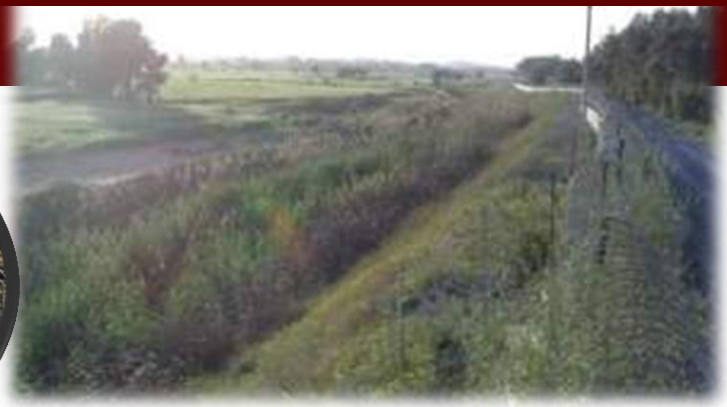


Resting and Feeding behavior



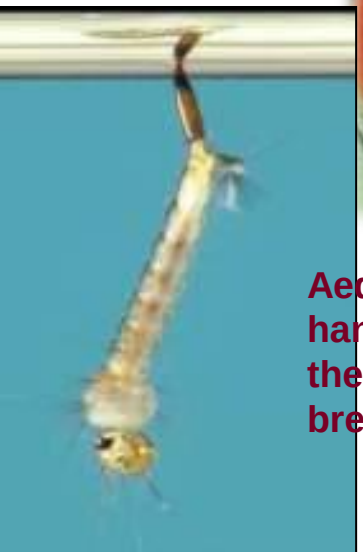
Behavior & Habitat Comparison





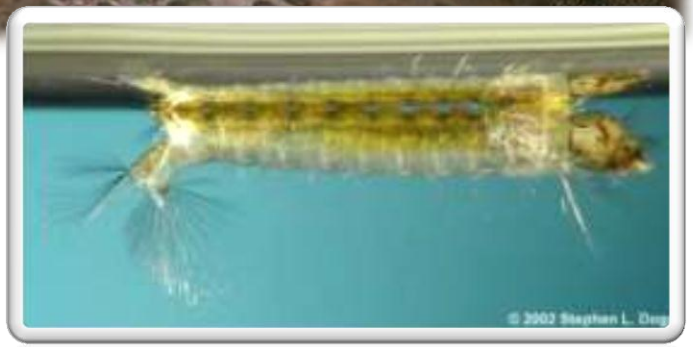
Aedes, Culex: stagnant, dirty, temp pools, opportunistic

Anophelines: typically cleaner, slowly flowing; in some places temp pools ok as long as not stagnant



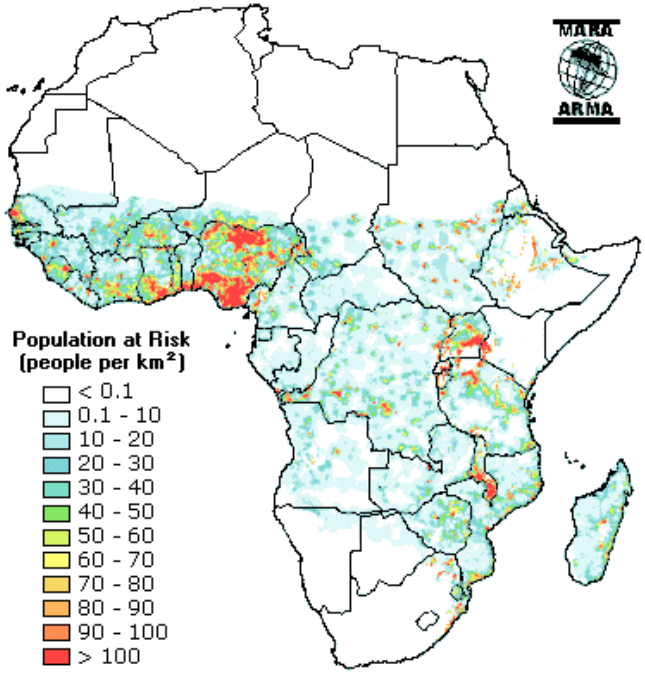
Aedes, Culex: body hangs down from the surface; uses breathing tube

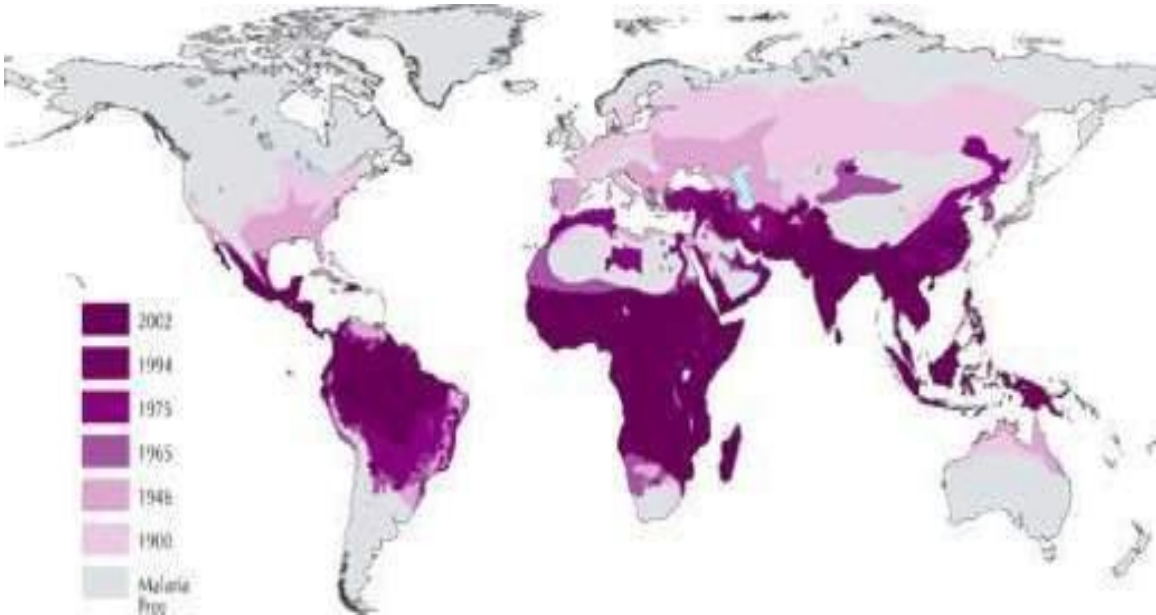
Anopheles: parallel to surface; spiracular plates on 8th abdominal segment



Malaria- Mosquitoes

- Risk varies geographically
  - Different species of ***Anopheles*** mosquitoes (varying competence)
- Entomological inoculation rate (EIR).
  - An estimate of exposure to infective mosquitoes
  - EIRs can exceed 1 infective bite per person per night

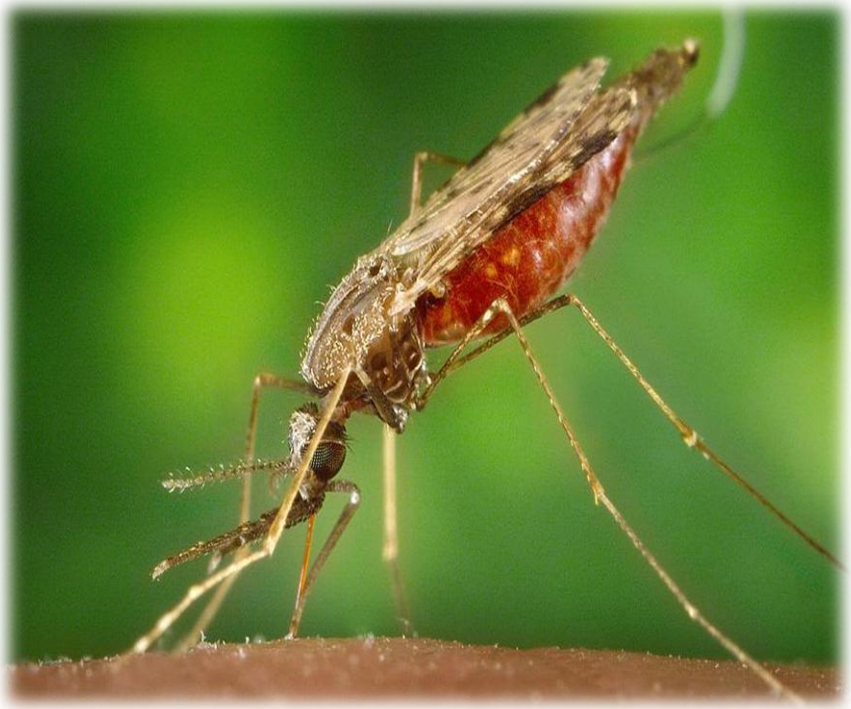




Biology of *Anopheles spp.*

Adult:

- Live from 3 to 4 weeks although some can overwinter.
- Feeding occurs at night (dusk to dawn).
- Host preference varies by species.
- **Indoor vs. outdoor feeding.**



Aedes Vectors

Aedes albopictus

Aedes aegypti

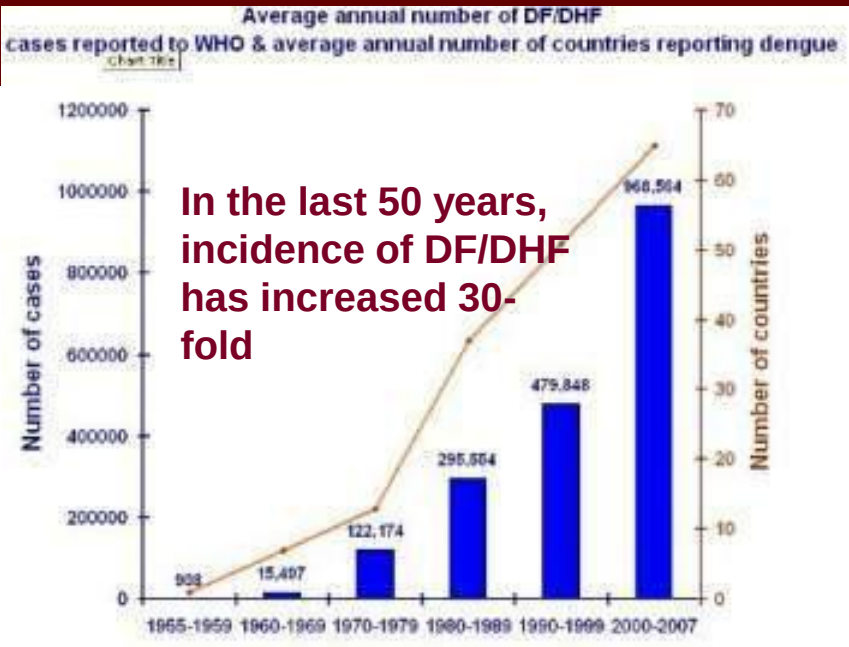
Aedes comparison

Ae. aegypti

Ae. albopictus

Environment	**Urban**	**Forest**
Breed/feed	**Indoors(< 200m)**	**Outdoors**
Container type	**Artificial**	**Natural and artificial**
Biting peak	**Daytime**	**Dusk**
Host	**Human**	**Human/Vertebrates**
Flight Range	**< 200m**	**< 600m**

Dengue



In the last 50 years, incidence of DF/DHF has increased 30-fold

- Endemicity has increased from 9 countries to over 100 countries since the 1970s
- The dengue transmission cycle occurs in the US
- No vaccine; treatment basically limited to supportive care

<u>As of fall 2013:</u>

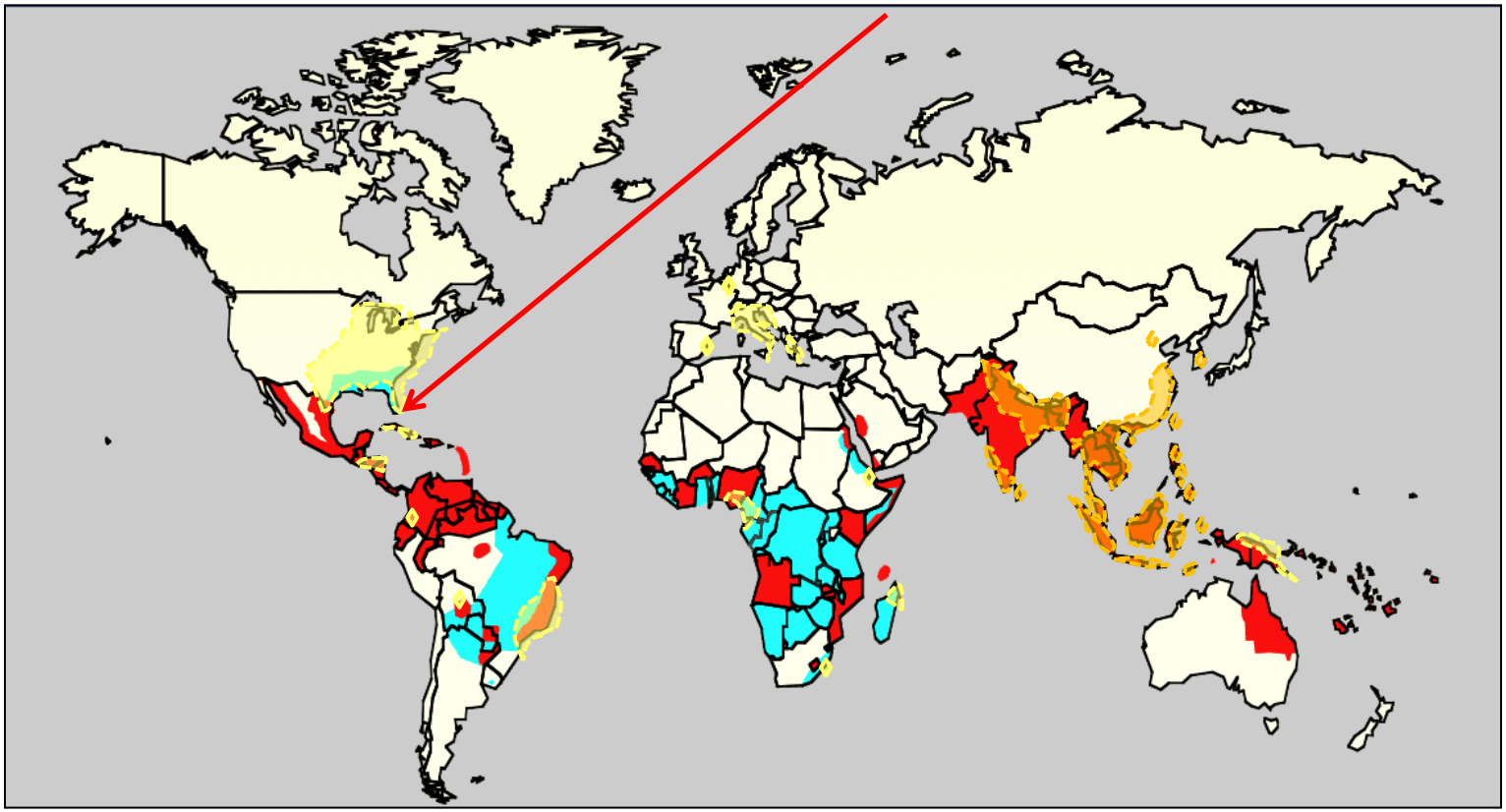
- The Americas- 876,859 cases; 406 DHF/serious
- Vietnam- 13,903 cases
- Laos- 14,000 cases, 50 dead
- Malaysia- 11, 485

-First case of secondary transmission in Miami in 50 years in Nov 10; 2 cases in 2011; first case of secondary transmission in Tampa diagnosed in Oct 2011; 4 cases in 2012; 28 cases in 2013 Martin County outbreak

"Dengue virus returns to Florida after more than 50 years, UF researchers say" UF News, 23 Nov 09

-27 locally transmitted cases confirmed in 09, 66 in 2010 (Key West)

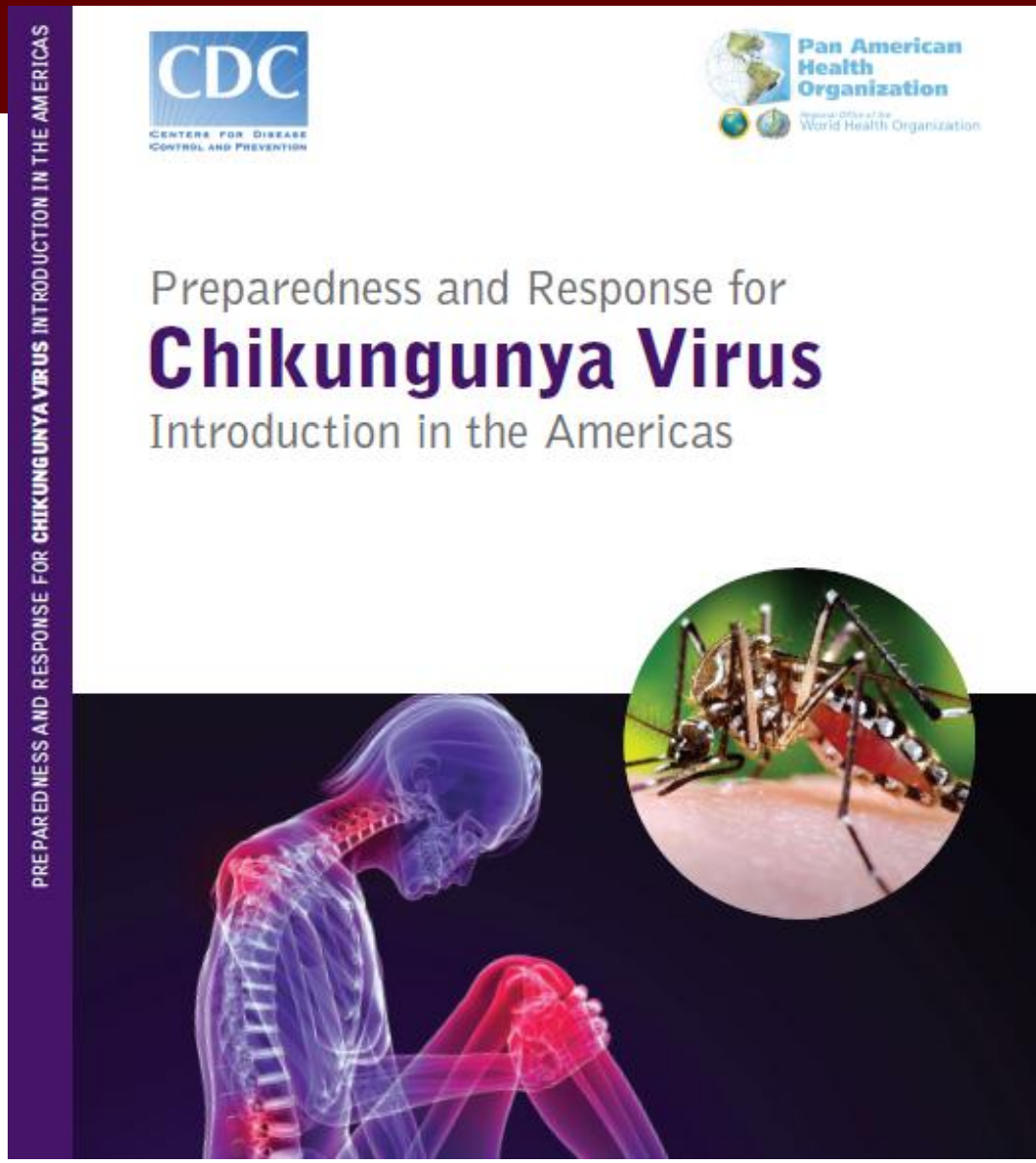
VECTOR INFLUENCE



Epidemic dengue:
Ae. aegypti distribution:
Ae. albopictus native range:
Ae. albopictus introduction since Dec 07:

Chikungunya Fever

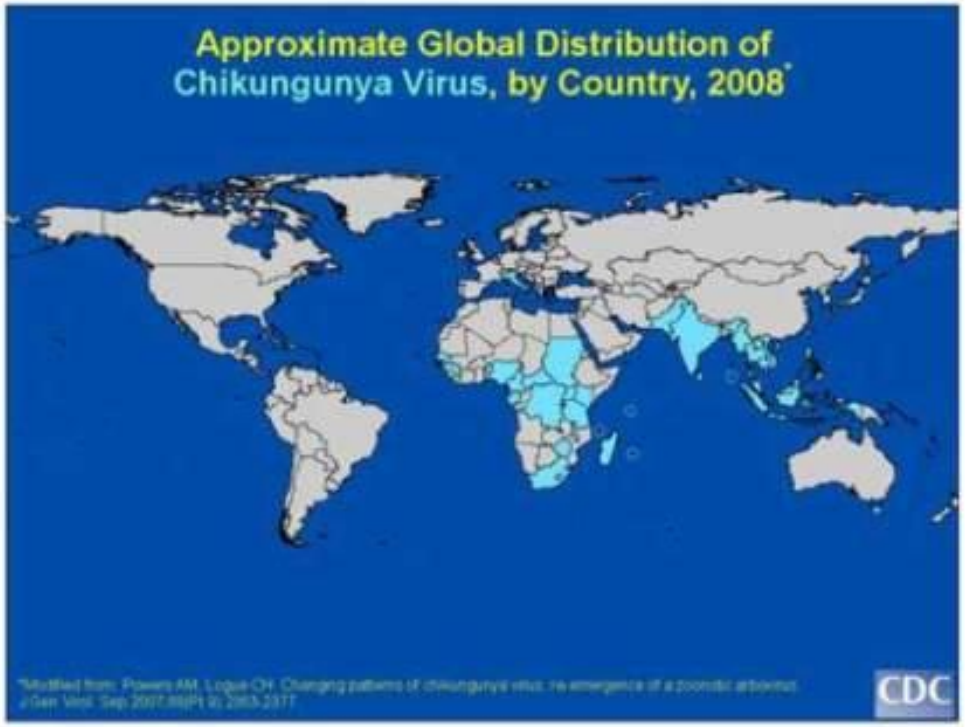
"From 2006 to 2010, 106 laboratory-confirmed or probable cases of chikungunya were detected among travelers returning to the United States. This compares with only three cases reported from 1995 to 2005. Since 2004, chikungunya virus has caused massive and sustained outbreaks in Asia and Africa, infecting more than 2 million people, with attack rates as high as 68% in some areas. With the movement of travelers, local transmission has taken place in areas where the virus was not previously found, including northern Italy and southern France." -PAHO/WHO



http://new.paho.org/hq/index.php?option=com_content&task=view&id=6464&Itemid=1926

Chikungunya Fever

- Mosquito-borne virus
- Like dengue, traditional vector is *Ae. aegypti* but *Ae. albopictus* is competent vector; equivalent eradication challenges
- Symptomology also comparable to dengue
- Continuous outbreaks since 2005 in Europe, Asia & Africa, to include areas not previously endemic; over 200 cases in Italy in 2007
- Caribbean outbreak 2014- over 230,000 cases



Sep 2014- US imported CHIK-V cases reaches >1050; 45 states affected; eleven cases of secondary transmission in FL

Filariasis

Vector depends on the geographic area

-Africa: *Anopheles*

-Americas: *Culex quinquefasciatus*

-Pacific and Asia: *Aedes* and *Mansonia*

Biting behaviors matter!

Sand Flies

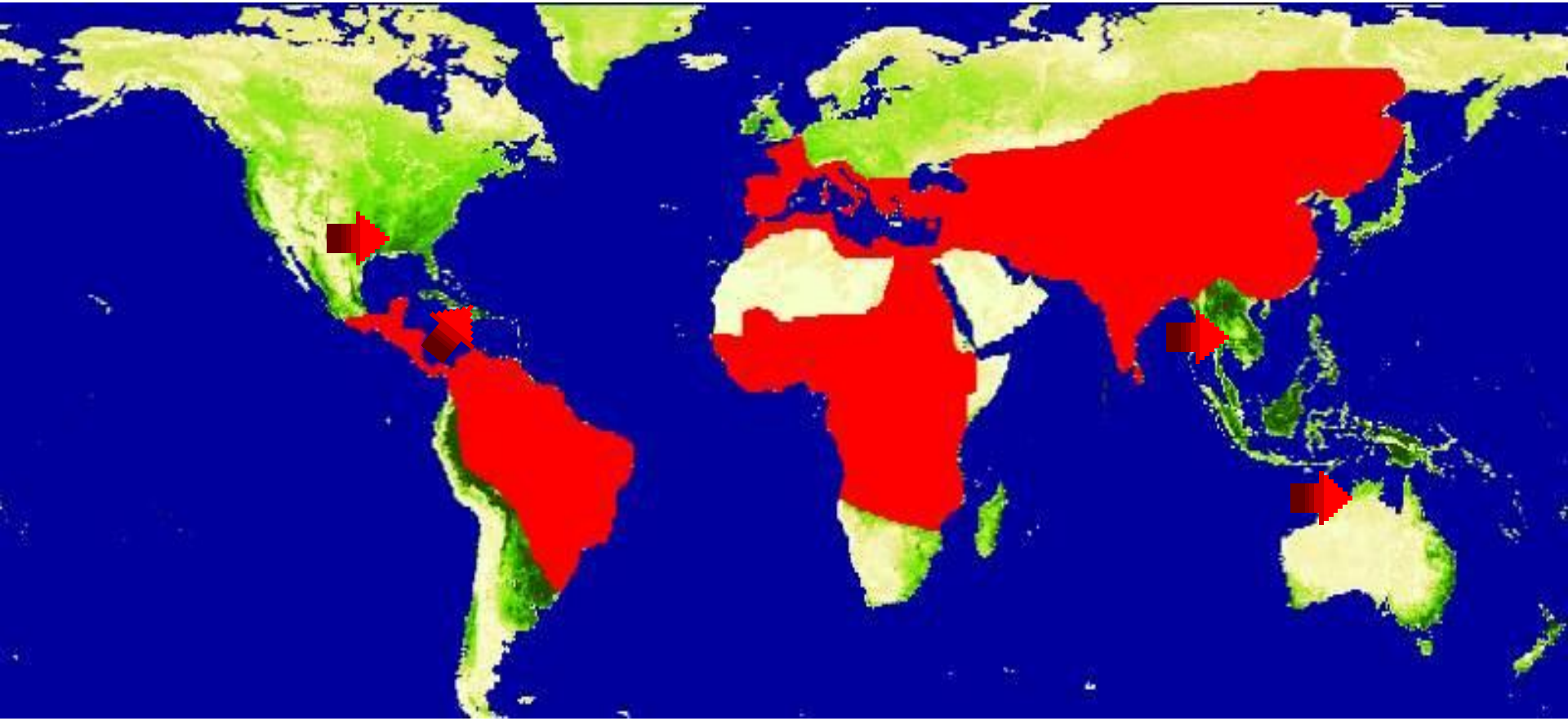
Characteristics

- Small (2-3 mm)
- Brown (but appear white when illuminated)
- Wings held in erect V-shape (even dead)
- Nocturnal
- Do not hover
- Silent
- Painful bite for some

Sand flies – vital requirements

- Larvae breed in soil (not aquatic)
- Only females take blood, from a variety of vertebrate species
- Rest during the day in dark, humid microhabitats
- Both sexes require sugar as an energy source

Global distribution of the leishmaniases (but not the global distribution of sand flies)

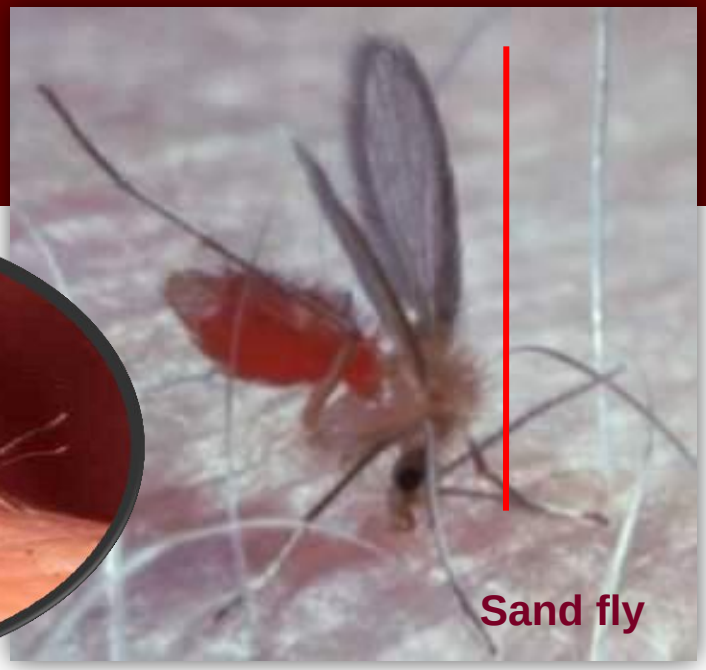


BITING BEHAVIOR

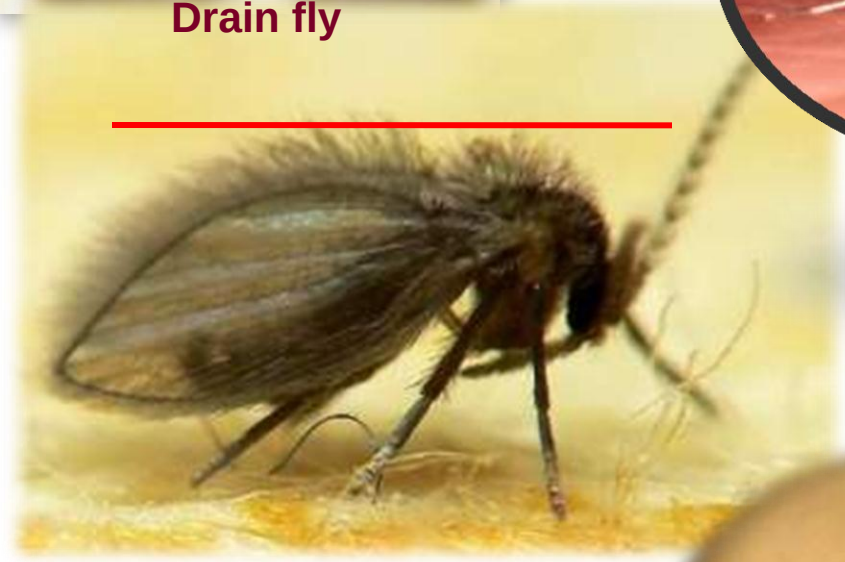
Cutaneous Leishmanisis Ulcers

Psychodidae:

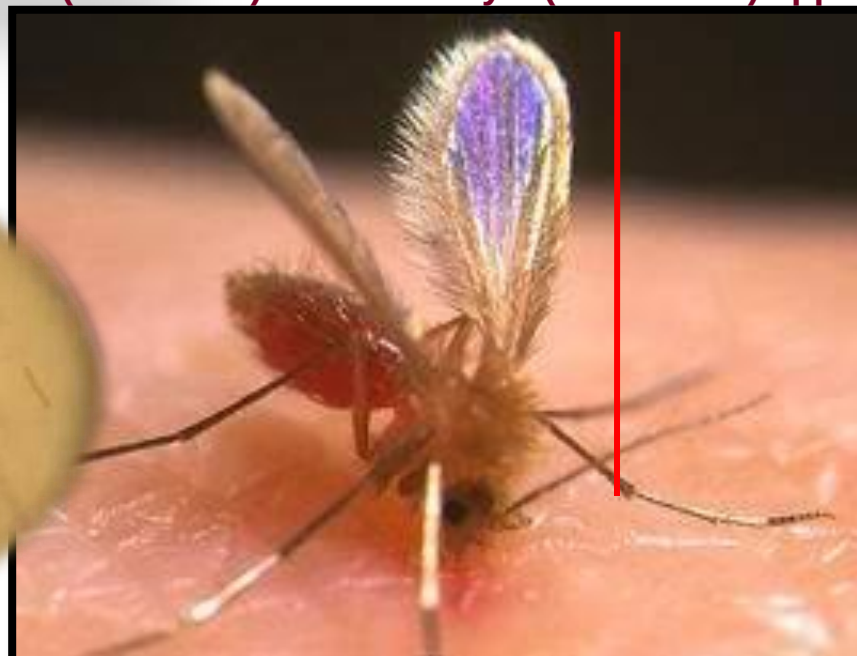
Drain fly



Sand fly



Phlebotomus (Old World) and Lutzomyia (New World) spp.



Damp habitats, plumose antennae, larger, broader wings, more hair; sand fly always holds its wings up and away from its body, not flat like a drain fly

Variable Habitats:
Rain Forest, Desert, Mountains, Cities

TICKS

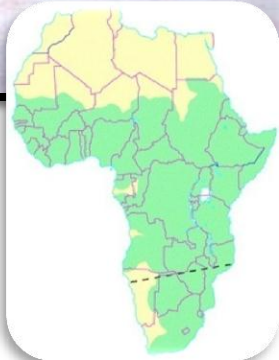
Tick Borne Diseases

- Lyme disease
- Ehrlichosis
- Rocky Mountain Spotted fever
- Babesiosis
- Spotted fever group rickettsioses
- Tick borne encephalitis (TBE)
- Crimean Congo Hemorrhagic Fever (CCHF)

African Tick Bite Fever- Ticks

African tick-bite fever (ATBF)

- an emerging infectious disease endemic in sub-Saharan Africa
- the most commonly encountered rickettsiosis in travel medicine.
- *Rickettisia africae*
- *Amblyomma,*
- *Dermacentor*
- *Riphicephalus*

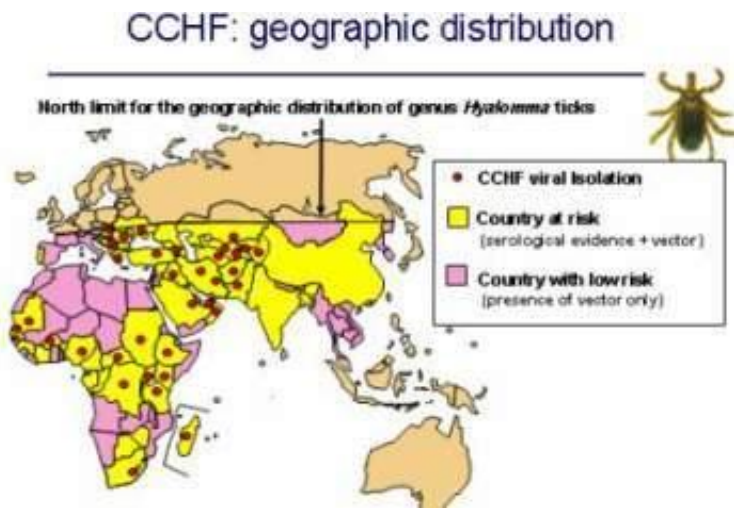


1. Ndip et al., 2011. Risk Factors for African Tick-Bite Fever in Rural Central Africa. *Am. J. Trop. Med. Hyg.*

2. Raoult et al., 2001. *Rickettsia africae , a tick-borne pathogen in travelers* to sub-Saharan Africa . *N Engl J Med*

Crimean Congo Hemorrhagic Fever

- **First US Soldier death from CCHF since WWII occurred in Afghanistan in Sep 09.**
- Tick-borne virus with a 30% mortality rate
- **Can also be transmitted by exposure to fresh infected blood (human or animal)**
- Endemic in many countries in Africa, Europe, Asia and the Mediterranean; since 2001 cases or outbreaks have been recorded in Kosovo, Albania, Iran, Pakistan, Georgia and South Africa
- **Most widely distributed HF in the world**
- **Austere conditions increase the likelihood of transmission; fewer "tick checks", formal or informal**
- Intensive monitoring of blood volume and component required



Tick Removal

U. S. Army Center for Health Promotion and Preventive Medicine

REMOVE TICKS PROMPTLY

If a tick is found attached to the body (Figure 1), seek assistance from medical authorities for proper removal, or follow these guidelines:

(1) **Grasp the tick's mouthparts** against the skin, using pointed tweezers (Figure 2).

(2) **Pull back** slowly and steadily with firm force.

(a) Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter (Figure 2).

(b) **BE PATIENT** – The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time-consuming (Figure 3, inset).

(c) Most ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh, further adding to the difficulty of removal.

(d) It is important to continue to pull steadily until the tick can be eased out of the skin (Figure 3).

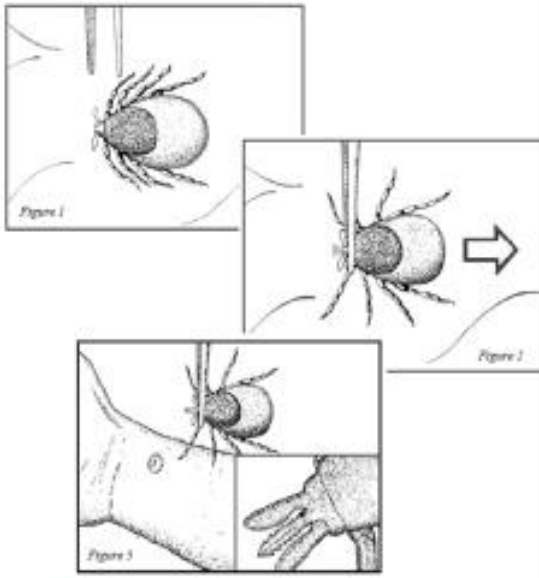
(e) **DO NOT** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, do not panic. Embedded mouthparts are comparable to having a splinter in your skin. Mouthparts alone cannot transmit disease because the infective body of the tick is no longer attached. However, to prevent the chance of secondary infection, it is best to remove them. Seek medical assistance if necessary.

(f) **DO NOT** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound site.

(g) **DO NOT** apply substances such as petroleum jelly, finger nail polish, finger nail polish remover, repellents, pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective, or worse, might agitate the tick and cause it to force more infective fluid into the wound site.

Following removal of the tick, wash the wound site (and your hands) with soap and water and apply an antiseptic.

Save the tick for future identification should you later develop disease symptoms. Preserve it by placing it in a clean, dry jar, vial, small Ziploc plastic bag, or other sealed container and keeping it in the freezer. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.



You may discard the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

A tick needs a blood meal from a host in order to molt (progress to the next stage of its life cycle), and to reproduce (lay eggs). This feeding process continues for several days to a week until the tick is fully engorged with blood. It then releases its hold on the host, drops off, and subsequently molts or lays eggs.

If the tick is infected with pathogenic organisms (for example, *Borrelia burgdorferi*, the agent of Lyme disease), it can transmit the infection to the host during the feeding process. As the tick feeds, the pathogens multiply, migrate to the tick's salivary glands, and are carried into the wound site along with the saliva.

Successful transmission of pathogens requires the tick to be attached for at least several hours. Therefore, the sooner infective ticks are removed, the less likely they will be able to transmit infection. It is impossible to tell if a tick is infected just by looking at it. Only analysis in a laboratory can determine infection status.

Entomological Sciences Program, Aberdeen Proving Ground, Maryland 21010-5403
October 2003

Chagas
(American Trypanosomiasis)

Romana's Sign from fecal contamination

7 known US autochthonous cases in 2008

- Multiple modes of transmission: vector, oral, congenital, transfusion, organ transplant, food-borne
- Curative treatment only possible in acute phase; <1% diagnosed in that phase; chronic disease will shorten lifespan due to cardiac effects
- Zoonotic (dogs are also a host)- increases difficulty of eradication
- Transmission occurs in the US (Red Cross believes 300,000+ in US are infected)
- Increasing cases of food borne Chagas; ecological influences? mission impact? increased caution regarding local food sources? US transmission concerns?
- Venezuela- 334 cases in the 1st three weeks of 2014; more than all of 2013

Chagas-Kissing Bug

Kissing bugs

Triatoma infestans

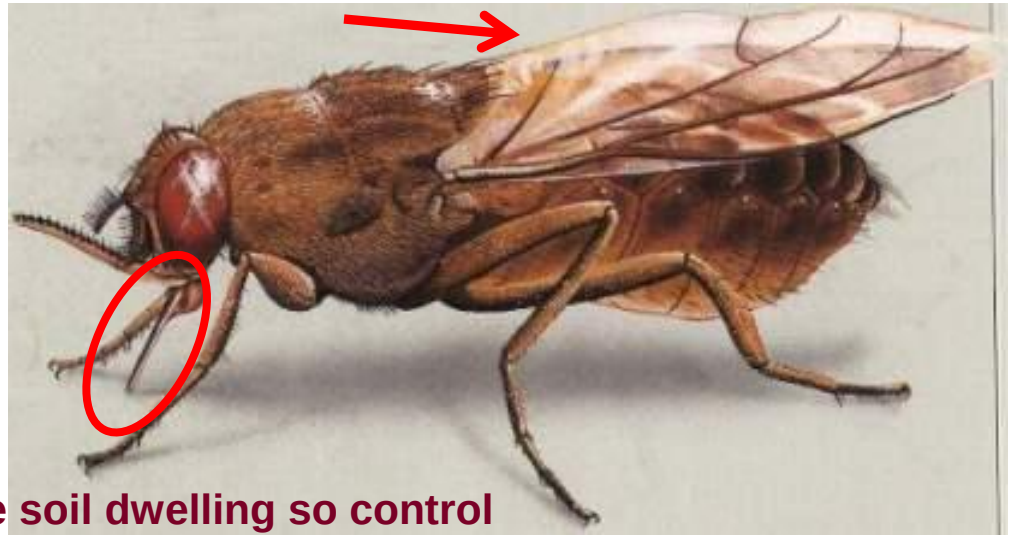
Rhodnius Prolixus

Assassin bugs

Sleeping Sickness

Over 50% of the landcover in Africa is considered <u>"highly suitable" to the tsetse fly</u>; both sexes take blood meals

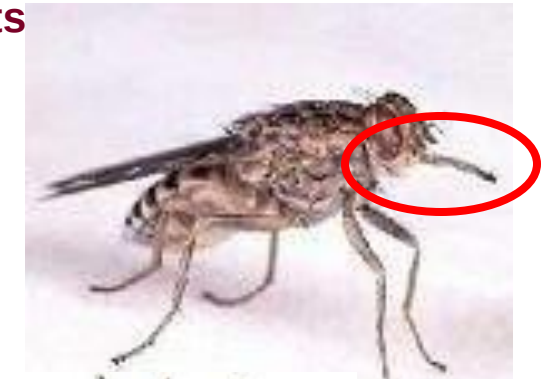
African Trypanosomiasis- Tsetse Fly



Muscidae sp.

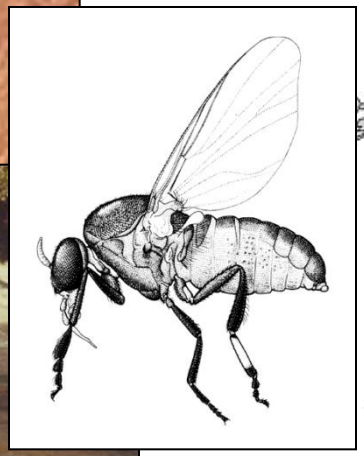
Larvae are soil dwelling so control measures target adults

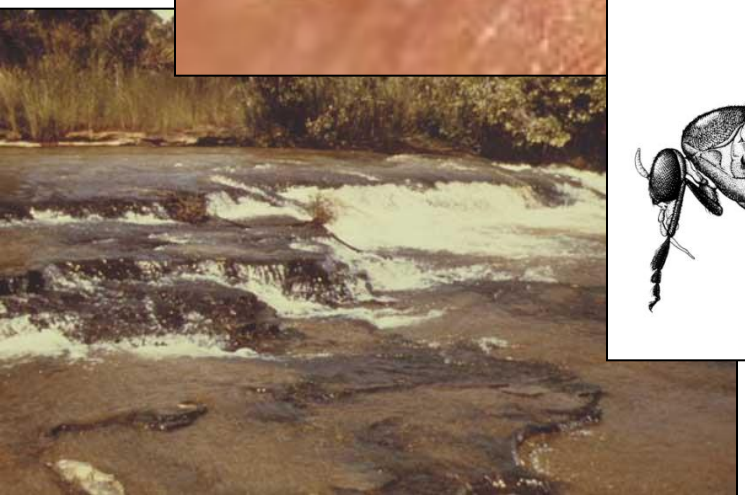
Glossinidae sp.



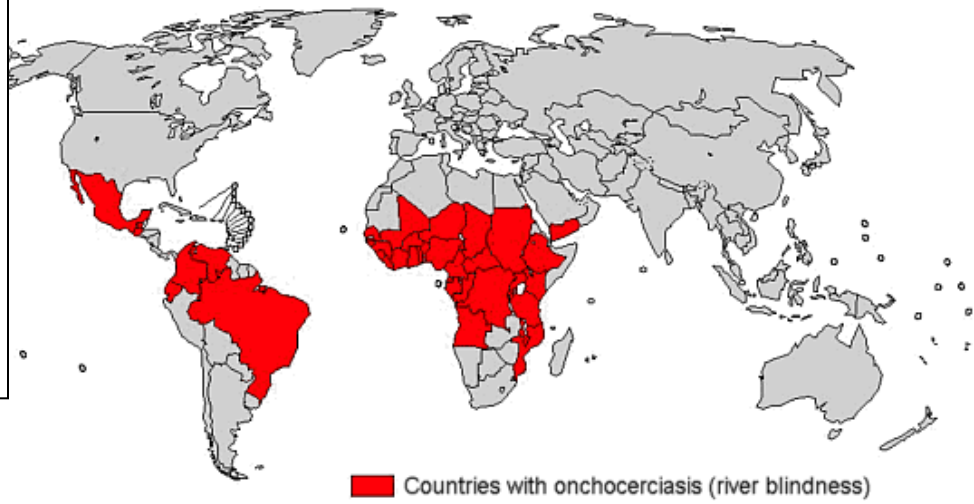
Distinct features: long proboscis, calyptrate attenae, ptilinal suture, the wings overlap completely when held over the abdomen, the discal medial (i.e. the middle) cell of the wing has a characteristic hatchet shape; and it has more bulk than the house flies.

Onchocerciasis- Black Flies





-*Simulium complex* breed in fast-flowing streams and rivers hence the commonly known name of “river blindness”
-Large flight range
-Larval stage is targeted by control programs
-Painful daytime bite; “pool feeders”, ideal for transmisson of microfilarial into skin
-Thousands of eggs can be laid at one time, outbreaks can be ecologically linked



PHYSICAL THREATS

Direct Injuries

- Insects in eyes, ears, and nose.
- Biting to feed w/o disease transmission.
- Myasis – humans as an incidental host for insects. Larva develop in an animal feeding on body fluids before emerging as an adult.

Why does the vector matter?

It’s not just about disease…

Bites and Stings

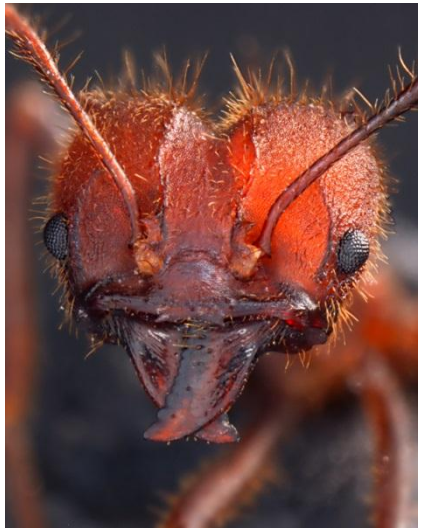
- Spiders, centipedes, scorpions, bees, wasps, etc… all inject venom when they bite or sting.
- Some envenomizations are only painful but some can cause death.
- Blister Beetles – excrete a chemical blistering substance that causes blisters.
- Uricating hairs – hairs from the arthropods that cause painful irritations on human skin.

Scorpion

Wasp

Solifugae (Camel Spider)

Leafcutter Ant



South African Wandering Spider

Honey Bee Swarm

Snakes

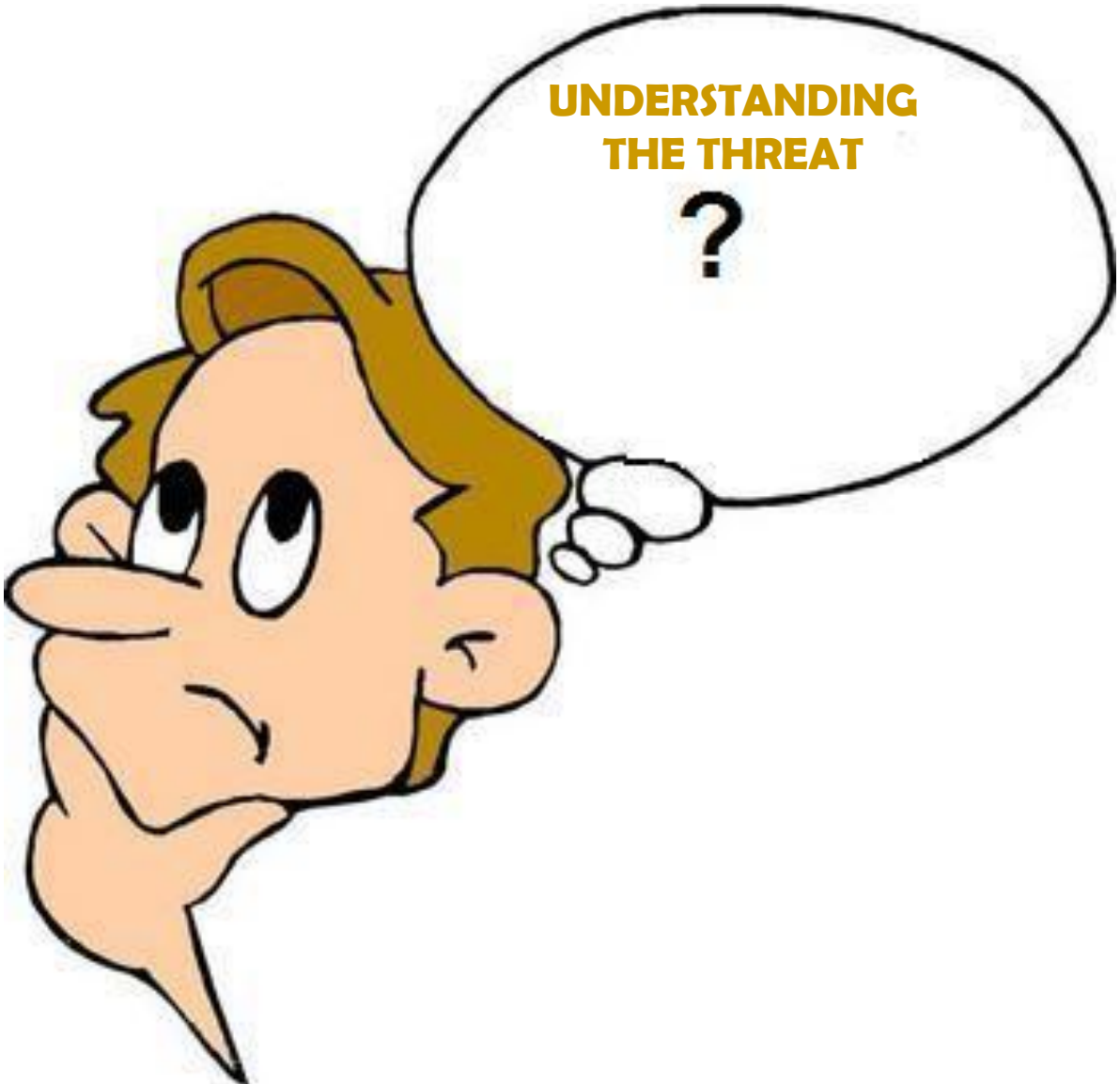
- Venomous vs. Non-venomous
  - Unless you are a snake expert you don't know and must assume all are posionus
- Viperids (Vipers)
  - True Vipers – Puff adders, Saw-scaled viper
  - Pit Vipers – Rattlesnakes, copperheads,
- Colubrids
  - Most are harmless but others have potent venom (Boomslang)
- Elapids
  - Sea snakes, taipans, coral snakes, kraits, death adders, mambas, king cobra and cobra's

Horned Viper

Milk Snake vs Coral Snake

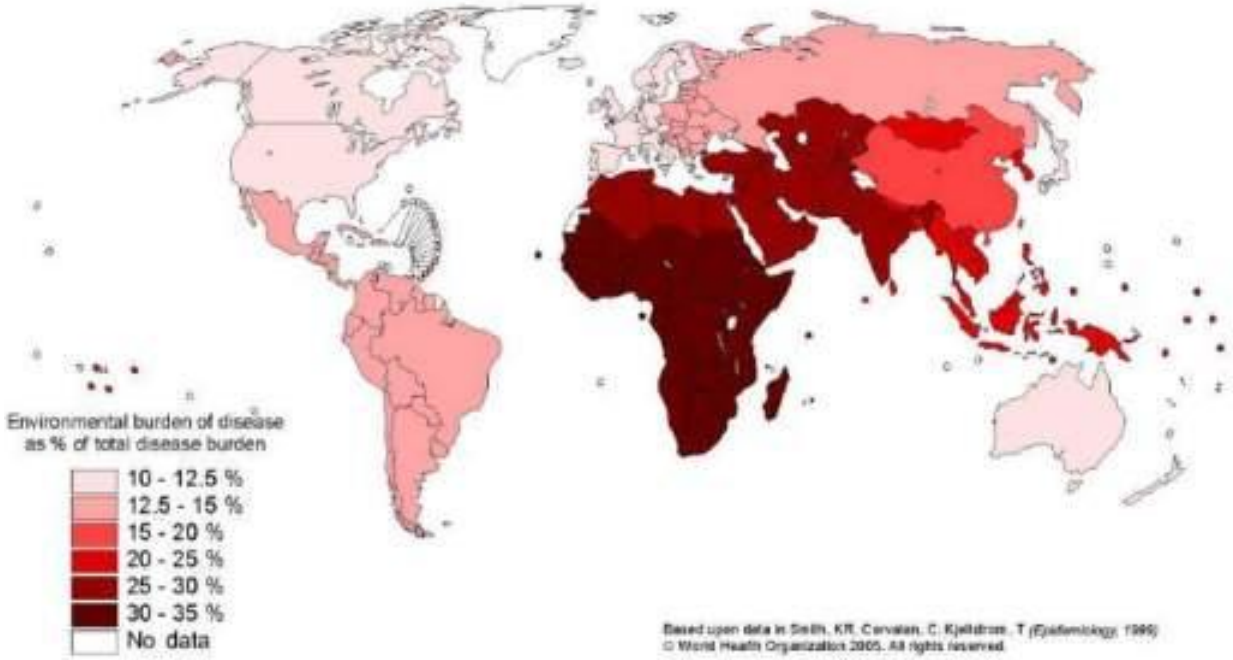
Cobra in the toliet

Rattlesnakes


UNDERSTANDING
THE THREAT
?

What are the threats in my AO?

Depends on **where** you are and **when** you are there.



Determining the Risk

1. What diseases are known to be present?

2. Will the mission put personnel into close contact with vectors?

- VECTOR BEHAVIOR
  - *Anopheles* mosquitoes are nighttime biters.
  - *Aedes* mosquitoes are daytime biters.
  - Sandflies typically fly close to the ground.
- VECTOR HABITAT…Will personnel operate in areas with vectors?
- BILLETING…in buildings with doors and screened windows?

3. Will conditions support disease transmission?

- SEASONALITY
- RECENT WEATHER (rain and mosquitoes, wind and sand flies)
- DENSITY OF VECTOR
- INFECTION RATE

Where will you be staying?

Tents?

Huts?

Environmental Units?

Help in Identifying Priority threats

- **Entomological Operational Risk Assessments (EORA)**

- Provide risk estimates for vector-borne and zoonotic diseases in the country of concern.

- These estimates, prepared by USAPHC.

- EORAs available for >30 countries.

- **Infectious Disease Risk Assessment (IDRA)**

- NCMI

- Web-based and CD (MEDIC)

- Classified and unclassified medical intelligence/information

- **Disease Vector Ecology Profiles (DVEP)** http://www.afpmb.org/content/disease-vector-ecology-profiles

- **Geosentinel**
- **ProMed**

REGIONAL RISK

DVEPS

- Provide risk estimates for vector-borne and zoonotic diseases in the regions of concern.
- Prepared by AFPMB.

Office of the Deputy Under Secretary of Defense for Installations & Environment

Regional Disease Vector Ecology Profile

South Central Asia

Defense Pest Management Information Analysis Center
Armed Forces Pest Management Board
Forest Glen Section
Walter Reed Army Medical Center
Washington, DC 20307-5001

Homepage: http://www.afpmb.org

September 2001

The Walter Reed Biosystematics Unit

HOME | VECTOR ID | WHO WE ARE | STAFF | WHAT WE DO | FAQS | FORUM

The Walter Reed Biosystematics Unit (WRBU) is a unique national resource. Its mission is to conduct systematics research on medically important arthropods and to maintain the U.S. mosquito collection. The WRBU is just one part of the U.S. Government's entomological research system, which includes the U.S. Department of Agriculture (USDA) and the Smithsonian Institution (SI). Historically, mosquito identification was managed by USDA and the SI, but in 1972 this responsibility was transferred from USDA to the U.S. Army for research on medically important arthropods. Located at the Museum Support Center of the Smithsonian Institution in Suitland, Maryland, the WRBU's physical space is provided by the Smithsonian Institution in return for curation of the collection and specimen identification... *(more)*

What's New?

Mosquito Classification 2010

Discussion Forum

New mosquito identification keys

See new WRBU staff publications

VectorMap

MosquitoMap.org
SandflyMap.org
TickMap.org

WRAIR

AFPMB

Vector Identification Resources

to medically important arthropods and WRBU's Vector Identification Service

Mosquito Resources

Culicidae Catalog
www.mosquitocatalog.org

Mosquito Genera

Mosquito Literature

Medically Important Mosquitoes

Mosquito Species Identification Keys

Other Vectors

Sand Flies

Ticks

Scorpions

Fleas

http://wrbu.si.edu/

VectorMap

- Comprised of MosquitoMap, SandflyMap and TickMap
- Geospatially referenced clearinghouses for arthropod disease vector species collection records and distribution models.
- Users can pan and zoom to anywhere in the world to view the locations of:
  - past **vector collections** and
  - the **results of modeling that predicts the geographic extent of individual species.**

http://mosquitomap.nhm.ku.edu/vectormap/

VectorMap is new and still in the test phase.

Requires you to download Silver Light freeware from Microsoft.

Resources

- Command PM assets
- Regional Public Health Command (PHC), Ento Div

  http://chppm-www.apgea.army.mil/ento/default.htm
- AFPMB www.afpmb.org
  - Living Hazards Data Base
  - Disease Vector Ecology Profiles (DVEPS)
- National Center for Medical Intelligence (MEDIC CD)
- WRAIR Entomology Division
  - Walter Reed Biosystematics Unit (WRBU)

    http://wrbu.si.edu

    http://mosquitomap.nhm.ku.edu/vectormap/

PERSONAL PROTECTION

What can you do to minimize risk?

- Find out what the priority risks are in your area before you deploy.
- Understand the vectors so you can avoid them.
- Implement Personal Protective Measures
  - Use **repellents**
  - Sleep under insecticide treated netting
  - Wear permethrin treated uniforms
  - Take malaria chemo if directed

DEET

- DEET is the active ingredient in many insect repellent products.
- EPA reviews of DEET in 1998 and 2014 did not identify any risks of concern for human health.
- DEET products come in many formulations including: lotions, sprays, liquids, impregnated materials (towelettes).

Picaridin

- Picaridin is a colorless, nearly odorless liquid active ingredient that is recommended by the AFPMB as an alternative to DEET.
- Lab and field studies of products containing picaridin (10-20%) indicate good protection.
- 7.5% products are not as effective.

- Natrapel, 20%, 3.5-oz. Pump Spray
  NSN 6840-01-619-4795

AFPMB Approved Repellents

- DEET
  - Ultrathon by 3M 6840-01-284-3982
  - Ultra by Sawer 6840-01-584-8393
  - Cutter Pump Spray 6840-01-584-8598
- Picaridin
  - Natrapel pump spray 6840-01-619-4795

Treated Uniforms

- Permethrin is the repellent EPA registered to treat clothing.
- The Marines and Army are currently issuing factor treated uniforms.
- Permethrin treated clothing is sold commerically.

Bed nets

Enhanced BedNet System 3740-01-546-4354

Improved Bed Net System 3740-01-543-5652

Bed net, Pop-up, self-supporting

Coyote Brown 3740-01-518-7310

OD Green (Camo) 3740-01-516-4415

NSN 3740-01-518-7310- CL 0X item, must be ordered through CL IX SARSS

The pop-up bed net is factory-treated with permethrin and has much finer mesh than the standard military bed net.

Myth Busters

- No evidence that eating garlic or taking vitamin B tablets reduces mosquito bites.
- Dark clothing is usually more attractive than light colored clothing.
- Drinking alcohol may increase your attractiveness to mosquitoes.

Area Repellents

- Some mosquito control devices use repellents to protect a small outdoor area like a patio.
- No products are approved by the EPA for indoors.
- There are no area repellents currently approved for use by the DoD.

Myth Busters

- Sonic and electronic devices do not work.

Questions?

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